

## 15.

*Nocomis* Nests Used by Other Breeding Cyprinid Fishes in Virginia.

EDWARD C. RANEY.

Department of Zoology, Cornell University, Ithaca, New York.

(PLATE I).

## INTRODUCTION.

The observations reported below were made during the period June 18-28, 1946, while the author was engaged in ichthyological studies of streams of the Piedmont and Coastal Plain in Virginia and North Carolina. A grant from the Trustee-Faculty Committee on Research, Cornell University, financed a large part of the field work and all specimens mentioned herein are deposited in the fish collection of that institution. Assistance was given by Dr. Ernest A. Lachner and Robert D. Ross.

Little has been recorded on the habits of many of the minnows, Cyprinidae, of the regions visited. Of interest is the discovery that the Carolina chub, *Nocomis leptcephalus* (Girard)<sup>1</sup>, like other members of the genus, builds circular nests of small stones which are carried in the mouth of the male. Furthermore these nests are used as a spawning site by many of the other common minnows found in the same region. Similar nests built by the river chub, *Nocomis microgogon* (Cope), and the hornyhead chub, *Nocomis biguttatus* (Kirtland), in the late spring are a prominent feature of many streams of more northern and western drainages. Their common use as breeding places by several other minnows has been noted by Hankinson (1920, p. 8, and 1932, p. 317), Hubbs and Cooper (1936, p. 65), Greeley (1929, p. 172), Raney (1940a, p. 6; 1940b, p. 128; 1940c, p. 363), and Reighard (1943, p. 417). The species that most commonly use *Nocomis* nests are the common shiner, *Notropis cornutus* (Mitchill); rosy-face shiner, *Notropis rubellus* (Agassiz); stoneroller minnow, *Camptostoma anomalum* (Rafinesque); and redbelly dace, *Chrosomus erythrogaster* (Rafinesque). Several other cyprinids, such as the fall fish, *Leucosomus corporalis* (Mitchill); the cutlips, *Exoglossum maxillingua* (LeSueur); and the tongue-

tied minnows, *Parexoglossum laurae* Hubbs and *Parexoglossum hubbsi* Trautman, build similar structures which may also be used by some of the above mentioned fishes.

## NESTS.

*Nocomis leptcephalus* ranges from the James River system of Virginia south through Georgia. It is one of the most common fishes found in Piedmont streams and also occurs less commonly in mountain creeks. Most observations of activity over *Nocomis* nests were made on June 21-22 in the Roanoke River system, Virginia, but the nests themselves were commonly observed in other more southern drainage systems. The problem of obtaining materials for nest building is solved in sandy Piedmont streams by searching the bottom over a large area to obtain hundreds of minute stones. These pebbles were deposited in a circular pile which varied roughly from 1 to 2 feet in diameter and 6 to 12 inches in height. The nests were usually located just above the break of the riffle. Less often they were found in slow riffles or in quiet water often under a low overhanging branch which offered some shelter. These nests were one of the most important spawning sites for other common cyprinids. Compared with more northern streams a striking parallelism was noted both in the type of fishes present and their precise location over the nests. For example, *Notropis cerasinus* (Cope) which in part replaces *Notropis cornutus* in the Roanoke River system, occupies the same territory an inch or so above the pebbles. *Chrosomus oreas* Cope swarms low over the nest and almost touches the stones just like *Chrosomus erythrogaster* and *Camptostoma anomalum* in the north. *Notropis ardens ardens* (Cope), like the more northern *N. rubellus*, holds the area high over the other fishes which may be present at the nest. Although not closely related these two minnows are elongate fishes that assume a reddish nuptial coloration and occupy a similar ecological niche at breeding time.

Cope (1869, p. 209) also observed these nests of *Nocomis* in July, 1867, in the head-

<sup>1</sup> This name is used only provisionally for the chub found in the Roanoke River system. It appears to be a much different fish than the blue chub, the true *Nocomis leptcephalus* (Girard), described from the Yadkin River system at Salem, North Carolina. The systematics of *Nocomis* are now being thoroughly studied by Dr. Ernest A. Lachner, Pennsylvania State College.



waters of the Roanoke River. However, he erroneously guessed that they had been built by suckers and also failed to correctly interpret the activities of the associated species. Local suckers do not build pebble nests but usually breed over gravel in moderate riffles. Cope noted that eggs were deposited beneath piles of stones and that various minnows gathered to eat them, and also observed territorial behavior in some species. Although he gave few details his brief remarks are significant and are here quoted except that the nomenclature is changed to bring it up to date: "Refulgent shoals of *Clinostomus vandoisulus* and *Notropis ardens ardens* would lie close to the heaps down the stream, and when startled by the approach of a stranger, would disappear like the passage of a stream of blood in the current; or the inquisitive *Chrosomus oreas*, in his harlequin hues, and the graceful *Rhinichthys atratulus*, would try to force away the pebbles and reach the coveted store, while pairs of a scarlet *Notropis cerasinus* would chase each other in and out, and by their superior size and activity keep up a perpetual commotion among the industrious party. The *Camptostoma*, too, of pale tints, and painted fins, swimming in pairs on the bottom, would gather with ease whatever the stream carried from the burrowing *Chrosomus*."

#### TERRITORIAL BEHAVIOR.

On June 21, 1946, in Otter River, Roanoke River system, 4 miles northeast of Bedford, Bedford County, Virginia, three minnows, *Notropis cerasinus*, *Notropis ardens ardens* and *Chrosomus oreas*, were observed over a *Nocomis leptcephalus* nest. The stream was a rather fast falling, clear mountain brook about 75 feet wide on the average with long moderately fast riffles and short shallow pools. The temperature of the water was 70° F., and air 75° F., at 12:30 p. m. The nest was located near the head of a riffle in moderately swift water about 18 inches deep. The lower edge was lodged against a jutting slab of bed rock which projected about 10 inches above the stream bed and was obliquely located about 20 feet from the nearer bank. The small, flat pebbles were mostly from three-fourths to one and a half inch in diameter, were piled in a semi-circle, and reached to a height of about 8 inches against the downstream rock.

As the nest was approached about 10 male *Notropis ardens ardens* were seen facing upstream and jockeying for positions over the nest. This species was distinguished easily by the slender shape, a suffusion of reddish-purple over the back and sides of the body, and by a prominent patch of light colored nuptial tubercles on the top of the head. They were located 4 or 5 inches

above the stones of the nest. The larger males held the upstream positions while the smaller ones were forced to the apparently less desirable spots on the downstream and lateral boundaries of the nest. There was intense and constant competition for the entire nest area. The smaller males constantly attempted to better their position by moving forward into the territory of another. Any aggressive move was immediately met by a short savage rush by an adjacent male. The smaller male usually gave ground and actual contact seldom resulted, although the sharp, forward pointing nuptial tubercles on the snout and rest of the head are ideally placed for offensive action. A male appeared to regard the area within 3 or 4 inches of his body as his territory to be guarded against intrusion by any other male of the same species. However, no attempt was made to drive away any of the swarm of male *Chrosomus oreas* which covered the nest immediately below them. Female *ardens* surrounded but were largely concentrated below and at the side of the nest. When ready to spawn a female moved into the center of the nest. She appeared to collide momentarily with a male, but the precise details of the breeding activity were not clear. An outstanding characteristic of *ardens* was a notable lack of fear of observers standing only a few feet distant. Even after a seine was pulled over the nest the individuals that escaped immediately returned to carry on their nuptial activities. Despite their great nervous activity they were quite alert to floating objects. They quickly rose and engulfed any insect carried downstream by the current but rapidly returned to guard the same territory.

About 10 minutes after the nest was first observed a large male *Notropis cerasinus* assumed a position at the head of the nest. He was distinguished from *ardens* by his larger size, deeper body, greenish rather than red back, and by the less well developed tubercle patch on the head. Other male *cerasinus* soon moved in over the nest and established territories. They darted nervously about attempting to drive away the smaller male *Chrosomus* which were well established over the nest. However, they met with little success since the *Chrosomus* gave ground only temporarily. On the other hand *cerasinus* males did not often clash with male *ardens* which were conspicuous just over them. They were easily frightened by sudden movements of an observer and on such occasions moved rapidly away from the nesting area. Female *cerasinus* occasionally appeared about the periphery of the nest but actual spawning was not seen. The behavior over the nest was in general much like that of a related species, *Notropis cornutus*, as reported by Raney (1940a, p. 8).



BREEDING OF *Chrosomus*.

About 20 brilliantly colored male *Chrosomus oreas* swarmed immediately above the pebbles of the same nest. They attempted to hold a small territory which consisted of an area about two inches to either side. The duller colored females were mostly concentrated downstream but a few constantly entered or passed through the nesting area. Upon sighting a female the male usually left his holding and followed her. If she remained quiet, 2 or sometimes 3 males would crowd close about her and spawn. Several males followed females for distances up to 10 feet from the nest only to return within a short time. Males dashed at each other in case of the intrusion of one upon the territory of another but much of the activity was of the ceremonial type described by Reighard (1910, p. 1128) for the creek chub, *Semotilus atromaculatus* (Mitchill). They were somewhat disturbed by the presence of observers but soon returned to the area.

Further observations were made on June 22, 1946, in another stream in the same drainage system, South Fork of Chestnut Creek, just north of Sydnorsville, Franklin County, Virginia. Here about 30 male *Chrosomus oreas* were crowded over a *Nocomis leptoccephalus* nest that was located in quiet water about 10 feet above a riffle. A camera was set up on shore about four feet away from the nest and although the water was slightly turbid some photographs were obtained which show certain phases of their behavior. The brilliantly colored males were holding territories over the entire nest but were more crowded over the more desirable upstream slope where often a distance of only one or two inches separated them. Part of such a concentration over a section of the nest is shown in Pl. I, Fig. 1. The males fought to hold territories against infringement by other smaller males. Many females were seen usually on the downstream edge of the nest. Occasionally one moved up over the nest and was immediately joined by two males that took a position close to and on either side of the female. The spawning act occurred as they vibrated together, and its successful completion within a second was heralded by a rush of *Chrosomus* to the spot of spawning in search of eggs as shown in Pl. I, Fig. 2. The egg predators included the erstwhile parents and up to a dozen *Chrosomus* were seen standing on their heads eating the eggs which fell between the pebbles of the nest. Rarely spawning occurs with only one male taking part. He threw his caudal peduncle over that of the female and forced her against the bottom. Within a few minutes the flurry of egg eating ceased and the males returned to their ter-

ritories. At times a male followed a female or another male out of the nest. Occasionally a male appeared to tire of the activity of territory holding and went off downstream for several minutes. He was not observed to return to the same spot but forced his way into a position commensurate with his size and pugnacity.

During all this activity several other egg predators were searching over the surface of the nest. Small *Nocomis leptoccephalus* and fantail darters, *Catnotus flabellaris* (Rafinesque), were seen moving slowly about and were not challenged by the male *Chrosomus*. After a considerable period several adult male *Notropis cerasinus* took up positions at the head of the nest and began their persistent but rather futile attempts to drive away the male *Chrosomus*.

Cope (1869, p. 234) reported that *Chrosomus oreas* deposits its eggs toward the end of July in the mountain streams forming the headwaters of the Roanoke River, in Montgomery County, Virginia. Nothing else has been published on the spawning habits of this species. However, Smith (1908, p. 13) made a thorough study of the breeding habits of the southern redbelly dace, *Chrosomus erythrogaster*, in Illinois during the last half of May and the first two weeks in June. He found them breeding in shallow riffles in very large schools that consisted of a far greater number of males. The actual pairing is usually like that of *oreas* described briefly above.

No adult *Nocomis* were observed working on or spawning over any nest, but it probably was a little late in the season for most of them. They also are more easily frightened by observers and it takes a long time to condition them so that they will return to a nest.

## SEXUAL DIMORPHISM.

All three species, like other territory holding Cyprinidae, show marked sexual dimorphism. Male *Notropis cerasinus* are larger, more brilliantly colored, and have much better developed nuptial tubercles than females. The largest males are 3.5 to 4 inches in total length while the females rarely are longer than 3 inches. Nuptial males are brilliantly colored with reddish-purple on the sides except for the occasional scattered black scales that characterize this species. The cheeks and opercle are purple and the lips are red. The dorsum is dark with the mid-dorsal streak an iridescent green. All fins are reddish-purple with a milky white anterior border and a narrow clear edge on the posterior border of each fin. The base of the anal fin is milky white. Female *cerasinus* are silvery with some red about the snout and lips in an occasional individual. Large breeding tubercles are



scattered over the head and snout of male *cerasinus*. They are sharp-pointed and with a slight hook which is directed forward. A row of large tubercles line the lower jaw. Only slightly smaller ones are scattered over the back in front of the dorsal fin. Still smaller pearl organs are present on most of the scales. On the fins they are most pronounced on the dorsal surface of the pectorals. A scattering also occurs on the upper surface of the pelvic fins, on the upper third of the caudal fin, and a few line the anterior and lateral aspect of the first dorsal fin ray. In female *cerasinus* all ripe or nearly ripe specimens also had nuptial tubercles developed but to a lesser extent in size and number. Fairly large, forward pointing ones are scattered over the top of the head and snout. Relatively few small ones line the scales on the back in front of the dorsal fin and the upper surface of the pectoral fins. The character of the tubercles constitutes one of the best differences between *Notropis cerasinus* and *Notropis cornutus cornutus* which is distributed from the James River system northward in the Atlantic coastal drainage. Female *cornutus* are almost always devoid of tubercles, and the male has fewer on the head and back. Those on the head of *cornutus* are erect in contrast to the forward hooked ones of *cerasinus*.

Male *cerasinus* also differ at least at the breeding time in possessing a smaller anal papilla which is non-protruding, while that of the female is quite swollen and protrudes posteriorly. The pelvic fins of the male are longer and when depressed extend well beyond the origin of the anal fin while the shorter pelvic fins of the female do not reach the anal fin origin. The pectoral fins are also longer in the male and reach well beyond the origin of the pelvic fins when depressed. In the female they are smaller and do not reach the pelvic fin origin.

Sexual differences in the stream-lined *Notropis ardens ardens* are of the same type. The male averages only slightly longer and reaches its maximum total length between 2.5 and 3 inches. Only a few females reach a length greater than 2.5 inches, and some were spawning at a length of 2 inches. The male at breeding time is very brilliantly colored a deep, reddish-purple on the body and fins. The dorsum and iris are also reddish in contrast to *N. cerasinus*. Female *ardens* are silvery colored. On the top of the head and snout the large breeding tubercles are closely placed and appear as a large light patch against the darker background of the rest of the head. These tubercles are sharp and pointed forward. They gradually diminish in size posteriorly on the body but extend to the origin of the dorsal fin. A few large ones line the chin. Smaller tubercles occur on the scales

on the anterior half of the body. Sharp pointed tubercles that are directed posteriorly line the rays on the upper surface of the pectoral fins. A single row is found on the first ray while a double row is present on the other rays except the last or 4 rays which are naked. A few line the anterior and lateral edges of the first dorsal fin ray, and some are found on the first anal fin ray. In female *ardens* a few poorly developed ones are seen on the top of the head but do not break the surface. None were observed on the body or fins. In breeding males the anal papilla is small and does not reach beyond the anal fin origin. That of the female is large and swollen, and reaches posteriorly beyond the origin of the anal fin. The anal fin is inserted more anteriorly in the male. The distance from the hypural to origin of the anal fin goes 1. to 1.8 times in distance forward from the anal fin origin to the tip of snout while in the female this distance goes 1.9 to 2. times.

Female *Chrosomus oreas* average slightly longer than males. The larger females and males range from 2 to 2.7 inches total length although some of each sex are mature at 1.5 inches. In this connection it is pertinent to note that the territory-holding instinct is less well developed in this and other cyprinids where the sexes are nearly equal in size than in those where the male are notably larger. A male *oreas* in high breeding color is one of the most brilliant vertebrate animals known. The lower side and belly are blood red. The fins are yellow. The yellowish-brown dorsum is covered with large dark blotches (Figs. 1 and 2). The male has 4 very light spots which perhaps serve as recognition marks. They are located anterior to and just above the base of the pectoral fin; just below and behind the eye, above the opercle, and on the back at the origin of the dorsal fin. These are absent or very dull in the female and are not seen at a distance. The black undersides of the head and the breast as well as the black lateral band on the body are much more intense in the male. Normally breeding females are rather dull colored and with little, if any, red and with small black spots on the back. However, one exceptional female with very large eggs was colored as brightly as any male, and also had well developed breeding tubercles. This assumption of the male nuptial color by the female apparently occurs occasionally in practically all cyprinids. The males have the head and body covered with small light colored pearl organs with the former being slightly larger. A double row of rather sharp tubercles line the upper edge of the second to fourth or fifth pectoral fin rays. A few scattered ones are found on the dorsal side of



the pelvic fins and along the lateral edge of the first dorsal fin ray. From 6 to 8 rows of comb-like tubercles line the breast on either side immediately posterior to the gill clefts. They are also present in the female but are smaller and not apparent except on close examination. Females also have small tubercles scattered over the head, dorsum and sides of body but none were observed on the fins. In the male the pectoral and pelvic fins are longer, reaching beyond the origin of the pelvic fins and anal fin respectively, while in the female neither of these points is attained. However, the female has a longer anal fin that is situated slightly more posteriorly on the body. In the male the anal papilla has a projecting tube on the median aspect of the posterior edge. The female lacks this posterior projection but the papilla is larger and has a median flap on the ventral side.

#### *Nocomis* × *Campostoma* HYBRIDS.

Six large specimens of an intergeneric hybrid, *Nocomis leptcephalus* × *Campostoma anomalum*, were collected on June 21, 1946, in the Roanoke River, 2 miles north of Allegheny Springs, Montgomery County, Virginia. At the same time numerous specimens of the parent species were taken. These hybrids were no doubt a result of a fortuitous combination of the sexual products as each of the parent species carried on normal spawning behavior over a nest of *Nocomis*. Cope (1869, p. 210), as quoted above, observed *Campostoma* over *Nocomis* nests in this region. In Michigan, Reighard (1943, p. 416) observed *Campostoma* carrying on spawning activities at the same time that *Nocomis micropogon* and two species of *Notropis* were breeding. Interspecific and intergeneric hybrids are known in several families of fishes<sup>2</sup> and some have been reported for the Cyprinidae. Other intergeneric hybrids involving either *Nocomis* or *Campostoma* have been recorded by Greeley (1938, p. 51) and Raney (1940d, p. 270).

A careful comparison of the hybrid with the parent species reveals they are intermediate in most structures. These results are in line with the findings of Hubbs (1940, p. 205) and have been confirmed in some other families of fishes by the results of laboratory matings. *Campostoma anomalum* is unique among minnows in having the long intestine coiled spirally about the air-bladder. In *Nocomis* the intestine is much shorter and the several loops lie entirely below the air-bladder. In the hybrid the intestine is intermediate in length. However, it is not coiled about the air-bladder,

but the ventrally placed loops come far up on either side of the air-bladder. The actual diameter of the intestine is also intermediate between the thin one of *Campostoma* and the relatively thicker intestine of *Nocomis*. The length of the air-bladder is also midway between the short one of *Campostoma* and the longer one of *Nocomis*. A well developed maxillary barbel is characteristic of *Nocomis* but is absent in *Campostoma*. The barbel came through in only one out of the six hybrids and is present on both sides and only slightly smaller than in normal *Nocomis*. It is generally true that the barbel does not appear in cyprinid hybrids when one of the parents does not possess it. A comparison of some other structural characters is presented in Table I.

Those characters that are common to the parent species are also possessed by the hybrid. For example, the peritoneum is black; anal fin rays 7; dorsal fin rays 8; pelvic fin rays 8-8; pectoral fin rays 16 or 17.

An examination of the gonads and nuptial tubercles yield some interesting points. The largest hybrid, 109 mm. in standard length, is a male with prominently developed tubercles. Indeed, it has the large, sharp-pointed ones on the top of the head of the type found both in *Nocomis* and *Campostoma*. On the back in front of the dorsal fin are a scattering of the smaller, rather blunt, tubercles that are found in breeding male *Campostoma* but which are absent in *Nocomis*. Numerous quite small tubercles are also present on the head and on the outer and upper surface of the pectoral fins. Slightly larger tubercles border the posterior edge of many of the scales along the sides. The testes are enlarged and were probably functional. Neither the dark bars to be found on the dorsal and anal fins nor the black spot on the caudal fin in breeding male *Campostoma* were seen on the male hybrid.

A small male, 83 mm. in standard length, shows the basal element of 17 large tubercles that never broke through the skin. They extend from the inner nasal region to the area midway between eye and occiput. Some very small tubercles are seen on the dorsal surface of the pectoral fins but are lacking elsewhere. The testes are little developed and this specimen had probably not matured and spawned.

The other 4 hybrids are females. The largest, 103 mm. in standard length, had well developed ovaries with a number of large normal-appearing eggs scattered through them. The bases of 12 large tubercles appear on the top of the head in the position described in the smaller male above. These are either scars or more prob-

<sup>2</sup> For a summary of investigations and further references on the subject of hybridization in fishes see Hubbs and Kurokuma (1942), Hubbs, Hubbs and Johnson (1943), and Hubbs, Walker and Johnson (1943).



TABLE I. COMPARISON OF THE CHARACTERS OF 6 SPECIMENS OF THE HYBRID *Campostoma anomalum* × *Nocomis leptocephalus* WITH THOSE OF THE PARENT SPECIES TAKEN IN ROANOKE RIVER, 2 MILES NORTH OF ALLEGHENY SPRINGS, MONTGOMERY COUNTY, VIRGINIA, ON JUNE 21, 1946.

Character	<i>Campostoma anomalum</i>	Hybrid	<i>Nocomis leptocephalus</i>
Cartilaginous pad on lower jaw	Well developed and separated from the lower lip by a groove. Pad protrudes well in front of lower lip	Somewhat developed and separated by a shallow groove from lower lip. Protrudes anteriorly only about half as far as in <i>Campostoma</i>	Not developed
Mouth, position of	Inferior	Intermediate	Subinferior
Ventral fin, location	Inserted farther forward; the distance from the posterior tip of hypural plate to origin of ventral fin, when measured forward, falls in front of tip of snout	Intermediate; the same distance, when measured forward, reaches a point well in front of nostril to a point beyond the tip of snout	Inserted more posteriorly; the same distance, when measured forward, reaches a point well behind nostril
Dorsal fin, location	Inserted farther forward; distance from posterior tip of hypural to origin of dorsal, when measured forward, reaches a point between the anterior nostril and tip of snout	Intermediate in five specimens; the same distance, when measured forward, reaches from a point in front of eye to the anterior nostril. In the sixth specimen, the distance reaches midway between the snout and anterior nostril and thus resembles <i>Campostoma</i>	Inserted more posteriorly; the same distance, when measured forward, reaches the eye
Scale rows			
Around body just anterior to dorsal fin	44 to 48	33 to 35	28 to 31
In lateral line	47 to 51	42 to 45	39 to 41
Length of head in standard length	3.8-4.3 (mean 4.1)	3.8-4.0 (mean 3.9)	3.4-3.8 (mean 3.6)
Intestine Length	Greater. Length of stomach plus intestine, divided by total length, equals 5.4 to 6.7	Intermediate—equals 4.0 to 4.1	Smaller—equals 1.5 to 1.9



ably incipient tubercles which did not break through the outer skin. Some female *Nocomis* have been observed to have similar pearl organs but they have not been seen on female *Campostoma*. Two other females, 86 mm. and 83 mm. standard length, also had the same type of breeding tubercles on the top of the head. The former had medium sized eggs in rather large ovaries while the latter had only small eggs in poorly developed ovaries. The 4th female, 60 mm. long, had no tubercles and only very small eggs in undeveloped ovaries.

Additional ecological studies of *Nocomis* nests covering a period of at least one season's activity would yield further information of great interest.

#### SUMMARY.

1. The Carolina chub, *Nocomis leptoccephalus*, a common minnow of the Piedmont streams of Virginia and North Carolina, builds a circular nest of pebbles in late June. They are similar to those constructed somewhat earlier in the year by other more northern and western species of *Nocomis*.

2. These nests are used as breeding sites by many other common minnows. In the Roanoke River system, Virginia, three cyprinids, *Notropis cerasinus*, *Notropis ardens ardens* and *Chrosomus oreas*, were holding breeding territories over one nest. Breeding behavior of *Chrosomus* was observed.

3. The three species show marked sexual dimorphism in such characters as size, coloration, development of nuptial tubercles, length of fins and the development of the anal papilla.

4. Six large specimens of an intergeneric hybrid, *Nocomis leptoccephalus* × *Campostoma anomalum* were taken with many specimens of the parent species in the Roanoke River. They are intermediate in most structural characters. Some of the hybrids had well developed nuptial tubercles and judging from the appearance of the gonads were functionally mature earlier in the season.

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## EXPLANATION OF THE PLATES.

## PLATE I.

Fig. 1. Part of a nest of *Nocomis leptocephalus* showing a group of male *Chrosomus oreas* scattered about. Each male may be easily identified by the prominent light spots on the back at the anterior base of the dorsal fin, just above the gill cover, and at the base of the pectoral fin. The large dark spots on the back are also characteristic of the male. Adjacent males aver-

age about 2 to 2.5 inches in total length and are two or three inches apart. Several dull colored females may be seen in the foreground.

Fig. 2. Same group of *Chrosomus* as above. In lower front are a group of males and females digging for eggs at a spot where spawning had just occurred. Other more distant males continue to guard territories.





FIG. 1.



FIG. 2.

NOCOMIS NESTS USED BY OTHER BREEDING CYPRINID FISHES IN VIRGINIA.



